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[71]Patent Holder: **G A O Gesellschaft für Automation und Organisation mbH**
Euckenstrasse 12
D-8000 München 70(DE)

[72]Inventor: **Becker, Wolfgang, Dipl.-Phys.**
Karl-Huber-Strasse 17
D-8014 Neubiberg(DE)
Inventor: **Merkle, Hansjürgen, Chem.-Ing.**
Bodenseestrasse 308
D-8000 München 60(DE)
Inventor: **Lass, Joseph, Dipl.-Phys.Dr.**
Hiltensbergerstrasse 29
D-8000 München 40(DE)
Inventor: **Hierweger, Alexander, Dipl.-Ing.**
Mühlbachweg 5
D-8183 Rottach-Egern(DE)
Inventor: **Lob, Erwin, Dipl.-Ing.**
Heiterwangerstrasse 4
D-8000 München 70(DE)
Inventor: **Kaule, Wittich, Dipl.-Phys. Dr.**
Lindacher Weg 13
D-8080 Emmerich(DE)

[71]Representative: **Klunker.Schmitt-Nilson.Hirsch**
Winzerstrasse 106
D-8000 München 40(DE)

[54] **Data carrier with an optical authenticity feature as well as process for the manufacture and testing of the data carrier**

[57] A data carrier, for example, an identification or a credit card, contains in its interior informations[1] that are introduced as irreversible modifications of optical properties by means of a laser beam. To be able to configure a more versatile optical impression of the data carrier, a plastic layer with a lenticulation is provided on the surface of the data carrier. The laser beam passes through the lenticulation and generates the desired optical information in the region underneath. The regions for the recording of informations is delimited by the lenticulation. Due to the effect of the lenses, the recorded information may be recognized only from certain angles. The apprehending of the information in its entirety occurs at the same angle at which the information was recorded before by means of the laser beam through the lenticulation. Photographic or electro-photographic copying of the data carrier is not possible.

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[1] translator's note: The patent makes intentional of the plural and singular of information. Although this is awkward in English, I am using this so as not to restrict the generality of the meaning.

Translator: Andrea-Ingrid Schneider, 715-549-5734 (German #1126/1995)

Data carrier with an optical authenticity feature as well as process for the manufacture and testing of the data carrier

The invention is concerned with a data carrier, where informations are introduced into an internal volume region by means of a laser beam, [and] which are visible in the form of changes of the optical properties based on an irreversible material modification caused by the laser beam, as well as with processes for the manufacture and testing of the data carrier.

Data carriers such as, e.g., identification cards, credit cards, bank cards, cash payment[2] cards, and the like are used increasingly in the most varied service industries; for example, for cashless financial transactions, as well as in-house areas. On the one hand, they represent a typical bulk article due to their wide use; their manufacture, i.e., the fabrication of the card structure and the introduction of the individual card user data, must be simple and cost-effective. On the other hand, the cards must be constructed so that they are protected to the largest extent against forgery and adulteration. The multitude of identification cards on the market and types still in the stage of development show the effort of the pertinent industry to optimize the two opposed conditions mentioned.

An identification card is known from DE-PS 29 07 004 for which the conditions named above are fulfilled. The process for manufacturing this known card is characterized in that the personal data are written by means of a laser to the already finished, laminated card. The card comprises an opaque card ticking[3] which is enclosed between two transparent cover layers. The writing process is done through the transparent cover foils. On one hand, the fabrication is substantially simplified by this [process], since no further fabrication steps are necessary after the personalizing, and on the other hand the security against forgery and adulteration increases, since the data are present in an unmodifiable form due to the destruction of material caused by the laser beam. For a suitable selection of the laser intensity, a marking congruent with the writing to the ticking may simultaneously be achieved within the volume of the cover foil up to its surface. The personal data are then present congruently in various layers of the card. In a special embodiment, a relief structure may be built into the surface of the cover foil as an additional marking, which may be checked easily even in a manual way. It thus also represents an authenticity feature and thus impedes to a large extent any manipulation or attempt to imitate such a card through forgery of the imprint.

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[2]literal translation; possible meanings: cash card, debit card
[3]strong, closely woven fabric

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It has already also been proposed (DE-PS 31 51 407) to provide a plastic layer as the recording medium within the card, which upon visual inspection appears completely transparent but sufficiently absorbs the laser light so that a blackening occurs in the foil under the influence of the laser beam. In this way, pictures and data may be introduced into essentially transparent layers, with a high resolution and very good quality of the writing.

Despite this high security against forgery and the relatively simple verifiability, one is further motivated to expand the possibilities of design for the card with regard to the visual imprint, and to further make adulterations and complete forgery of cards more difficult through the introduction of additional authentification features that can only be reproduced at large technological expense.

In this context it thus is known, for example, to introduce light diffracting elements, such as holograms or diffraction gratings (DE-OS 25 55 214 and EP 105 099). In this way, optical effects are given to the cards, which are simultaneously a protection against photographic or xerographic reproduction. Since usually the production of these holograms and diffraction gratings is very costly and expensive from a process engineering point of view, prices per unit for these elements are obtained that are reasonable for their use as identification cards only for mass productions in large scale manufacture. However, this mass production assumes that all holograms or diffraction gratings have the same informative content - mainly in the form of an emblem or a logo. The information is usually imprinted into plastic foils with an embossing stamp. The plastic foils are lined on the bottom with reflecting layers and the surface is sealed due to its mechanical sensitivity with a special lacquer. Then, during the manufacture of the card, the hologram or diffraction grating prepared in this way is mounted adhesively to the surface of the card. But such elements are a "foreign body" in the structure of a card and, for the production engineering reasons named above, cannot be provided with individual data adapted to each single card, o that in principle it is possible to remove these elements, e.g., from illegally obtained authentic cards, and transfer them to other false cards. Despite the high technological expense necessary for the fabrication of holograms or diffraction gratings, the essentially difficult reproduction of such elements may thus be avoided through the simple exchange or transfer to other cards.

It is moreover disadvantageous in the use of holograms and diffraction gratings in identification cards, that good lighting is necessary to visually check them. Even at normal room lighting the desired optical effects are shadowy or not recognizable at all. In place of that, the viewer sees only a metallic reflecting surface when examining a

hologram, or a slightly opalescent marking when examining a diffraction grating. Both effects are already imitable with easily obtainable so-called decoration materials, so that in the unfavorable lighting conditions mentioned they may not be distinguished by the layman from real holograms or diffraction gratings. They are thus only conditionally usable as an authenticity check formeans of payment, e.g., credit cards.

In the case of embossed holograms or diffraction gratings, the characteristic is further present in a relief structure, of which, with suitable means, a mold may also be created, which allows the reproduction of authentic holograms.

It also has already been proposed to equip for protection reasons brand name articles, e.g., music records, with authenticity markings (EP-A 78 320). The authenticity marking consists of a transparent foil which has a fine lenticulation (cylindrical lenses) on its surface. These lenses have a diameter of approx. 17 μ and lie on a polyester layer 100 μ thick, on whose back side there are arranged receptive layers for Polaroid photography. This structure may be exposed from the front side at various angles, and after development, one obtains on the photo-layer a fine line grating. The actual image information is generated by modification of the lens structure by embossing the cylindrical lenses in a partial region of the foil shifted compared to the remaining regions. These partial regions correspond in their shape to the motif to be introduced.

Since the pattern is introduced by the partial shift of the cylindrical lenses, from economic points of view this pattern is only suitable for the introduction of a large series of motifs remaining the same, similar to the already cited diffraction gratings.

Due to the necessary photographic development of the photo-layer lying underneath the lenticulation, it is further necessary to manufacture this element separately, and to fasten it as a prefabricated product to the brand name article or a label attached to the article. With that, it also represents a foreign body that is removable, and thus is transferable to other articles, where the photo-layer on the back side of the foil further facilitates the removal.

Therefore, the object of the invention consists in expanding the design possibilities for the data carrier with regard to the visual impression while maintaining the technological and security technological advantages of the laser writing process, where the data carrier shall contain features that are not photographically or xerographically reproducible, that can be machine-read and visually checkable in a simple way even in poor lighting conditions.

The means for attaining the object of the invention are the features contained in the characteristic of the main claim.

Processes for the manufacture of such data carriers as well as processes and arrangements for testing their authenticity are subjects of further co-ordinated claims.

In an advantageous embodiment of the invention, a lenticulation in the form of a plurality of cylindrical lenses arranged next to each other with the cylinder axes running along a straight or not straight line, and/or of spherical lenses, is embossed into a transparent foil layer of a data carrier that forms the cover foil. For this, the focal points of the single lenses may vary, e.g., corresponding to a given pattern, or else the cylindrical and/or spherical lenses may be arranged corresponding to a given pattern. This cover foil is preferably layered on top of another transparent plastic layer, whose optical properties change under the influence of the laser beam by, e.g., being blackened.

By means of a laser beam, informations are introduced through these lenses into the volume region of the data carrier lying underneath. The laser beam is held at a particular angle relative to the surface of the lenticulation. When passing through the lenses, the light of the laser beam is refocussed at the embossed lenses. The change in the volume region lying underneath restricts - presumably, also due to the increase in the power density due to the refocussing - to a more narrow delimited volume area relative to the original diameter of the laser beam. An information introduced this way is only visible at the same angle at which the laser beam hit the surface of the lenticulation, where the information is visible in a more or less large angular(region depending on the size of the discolored volume region. In the preferred example of embodiment in which essentially transparent foils are used for the recording, but which are sensitive to the laser beam, i.e., which discolor under the influence of a laser pulse with a certain pulse energy, these discolored volume regions may, at sufficient foil thickness, be generated in the shape of small rods that are oriented in the direction of the laser beam. Despite small pixel size (diameter of the small rods), such small rods have a high blackening density [when observed] at the necessary angle of observation, through which the ability of the laser information to be recognized is positively influenced to a particular extent.

With that, different informations can be introduced at various angles into the data carrier and [may be] clearly recognizable when viewed separately at the corresponding angles.

An information that was introduced with the laser, e.g., at a perpendicular incidence, may be, e.g., a logo, an emblem or an insignia. A further information, e.g., the expiration date is introduced at an angular deviation from the normal to the card of, e.g., plus 27°, and may be read again from that angle. A third information that is introduced from the opposite direction at an angle deviation of, e.g., minus 27° from the normal to the data

carrier, may be an information that varies from data carrier to data carrier (e.g., a serial number, or for bank related data carriers also an account number).

The data carrier exhibits therewith an optical characteristic that reproduces different informations at various viewing angles. Even though, like diffraction gratings and holograms, the image informations are only recognizable from certain viewing angles, the optical effect is not created by diffraction phenomena or interferences. According to the invention, the feature rather consists of at least one information contrasting to its surroundings that may unambiguously be checked without aiding devices, even in very poor lighting conditions, the same as usual "laser written image.

Through the corresponding control of the laser pulse power while writing to the foil, magnifications of the discolored volume region are achievable by means of which an information image may be written so that it is permanently recognizableregardless of the viewing angle. A combination of the effect designated in the following as "tilt-image" together with permanent data in the region of the lenticulation and further user-related laser personalized data in the area of the card surrounding the lenticulation area, which may be the same from the point of view of type-face and recording characteristics, facilitate the checking for authenticity and increase even further the security against forgery and/or adulteration. If the lasered[4] data overlap with product technological high quality printed images, e.g., with guilloche background print, as they are known from the state of the art, a particularly favorable linking of elements of security are achieved from the security technological point of view.

Through the process according to the invention, it is now possible to provide the finished data carrier, e.g., identification card, with such a tilt-image, where informations different from card to card may also be introduced simply through the corresponding control of the laser beam. By introducing individual card data into this tilt-image as an authenicity feature it is card specific, i.e., it is tied to a specific card and not transferable to other cards, as is the case for, e.g., the holograms and diffraction gratings cited at the outset. Significantly improved by the security against forgery, this individualizing is achievable practically without extra expenditure when using a computer controlled laser. The tilt-image is preferably recorded at the time when the usual personalizing is also done, so that all data are put together securely and correctly. It can herewith be prevented in a simple way that the card individual data of the tilt-image are mistakenly put together with the personalizing data of another card in the line of production. Since chemical

[4]In the original the noun *laser* was used to create a verb. I'm using the word *laser* as a verb that describes an action that uses the laser, without restricting to, e.g., writing or irradiating.

Translator: Andrea-Ingrid Schneider, 715-549-5734 (German #1126/1995)

development processes and the like are eliminated, the writing to the card is limited to one single processing step and thus particularly user friendly. The subsequent manufacturing steps that do not exclude destruction of the card (waste) are also eliminated.

If, e.g., a photo of the user of the card is introduced in place of the logo, then this image is permanently connected to the user-related individual data, e.g., the account number, and an exchange of photos between authentic and forged cards or imitated cards is thus also no longer possible. This essentially easy to perform irreversible linking of user related individual data to other image informations has a particularly advantageous effect and contributes to a great extent toward the security against forging of identification cards.

Furthermore, this tilt-image is reproducible neither photographically nor by means of copying technology, since the entire information is never available under one camera angle. Changing the tilt-image is not possible due to the type-face characteristic of the laser pencil. If the image is introduced, e.g., into the volume of transparent foils, then this is a further characteristic that is visually recognizable and that represents a further hurdle for imitating, since the technical problems are now so high and the effort necessary is out of proportion to the possible "gains".

The transparent foil with the imprinted cylindrical or spherical lenses as well as the foil carrying the information are preferably foils existing over the entire surface of the card structure and thus form an integral component of the card. Thus, a manipulation of the data usually has as a consequence the destruction of the card. If for a simpler card design a forger succeeds in separating the layered structure, the functi[illegible] reunification of the layers is prevented by the circumstance that the blackening in the deeper volume regions extends over several layers in the form of rod-like pixels, and due already to the unavoidable flow of material during the separating and/or reuniting process these may not be placed together so that the blackened volume regions are reshaped to their original form and location.

In such an attempt of manipulation, the forger further faces the problem that the lenticulation must be preserved during the separation of the foil as well as during reapplication. If the foil is removed by means of a hot iron, as customary during attempts of manipulation, a flattening of the lenticulation as well as a distortion of the foil is unavoidable, such that the reuse of the foil and therewith also of the card is not possible.

Therefore, the tilt-image also protects the card from delamination of the cover layer and the subsequent manipulation of any data existing on the inside of the card.

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Besides, a manipulation of the lasered data themselves is not possible since the laser causes an irreversible destruction of the card material.

The tilt-image may be introduced into the card during the personalizing process - corresponding to the teaching known from DE-PS 29 07 004 - while using the same technology (laser writing). The shipping of blank cards - not yet personalized cards - is not of concern, since this optical authenticity feature in the form of the tilt-image is not yet present in these cards and is only introduced during the last step of the work during the personalizing by means of relatively high technological expense. Only after the introduction of the tilt-image is the card consequently activated and obtains its "stamp of validity".

Further advantages and advantageous embodiments are subjects of the following description of the invention by means of the figures.

The figures show:

Fig. 1 a card according to the invention in top view

Fig. 2a, b, c representation of the single processing steps for the introduction of various partial informations,

Fig. 3 representation of the information visible under various visual angles,

Fig. 4 a-g various embodiments of a tilt-image according to the invention generated in a plastic layer,

Fig. 5 writing process in the dot-scanning procedure,

Fig. 6 a schematic representation of an examination device, and

Fig. 7, 8 further embodiments of the invention.

Fig. 1 shows an identification card that is provided with the usual general data, such as, e.g., the name of the user 2, and account number 3, a card number 4, and the specifications of the institution. The user specific data 2, 3 are burned, preferably with a laser, through a cover foil into an inner volume region, while the general data, such as, e.g., the specifications of the institution 5, are printed to one of the card layers by means of a printing technology process. An authenticity feature in the form of a tilt-image, whose structure and generation are described more closely in the following, is introduced into a partial region 8 of the card.

The card structure in a simple embodiment of such a card is shown in Fig. 2. The card comprises a core layer 6 of paper or plastic, to which informations are applied to the front or, as the case may be, also to the back by means of printing technological methods or according to the laser writing process known from DE-PS 29 07 004. The core of the card may further be equipped for increased security against forgery with a printed

security image and further security features, such as, e.g., water marks, security strip and/or other fluorescing substances.

The core layer is provided, at least on the front side, with a transparent cover layer 7. A relief structure in the form of several cylindrical lenses 15 arranged next to each other is embossed into a partial region of the surface of the cover layer. The field of view is narrowed due to the focusing through these cylindrical lenses, and when viewing the card from a certain angle only stripe shaped partial regions of a data carrying layer 12 are visible in the focal plane of the lenses.

Also other lens shapes, e.g., spherical lenses, or a mixture of different lens shapes may be used in place of the cylindrical lenses - obtaining the same effect. The cylindrical lenses may also run along undulating lines. Furthermore it is possible without problems, especially for card structures for which the writing occurs within the volume of transparent plastic layers, to vary the focal length and/or also the grid period within one lenticulation, where in the latter case the grid period may also be chosen such that it is smaller than the lens diameter. The position of the lenses may also be varied such that the vertices relative to the surface of the data carrier of lenses arranged next to each other lie at different heights.

Through the corresponding choice of the lens shape, the arrangement of the single lenses, the grid period, etc., the lenticulation may be formed in a shape typical for a specific type of card, where intentional patterns may also be introduced.

In this case, based solely on its specific relief structure, the lenticulation is already an authenticity feature that may be checked visually and/or by machine. Moreover, this represents a further hurdle for the forger, since he now may be forced to reconstruct the lenticulation specially made for a certain type of identification card or other intended use.

Suitable materials for the transparent layer equipped with the lenticulation are, e.g., plastics that at least up to certain intensities are transparent for laser beams, such as, e.g., commercially available PVC foils. These foils have the advantage that they may be well bonded to other plastic foils or paper layers of the card, e.g., by applying heat and pressure. For this, the single card layers are placed between heated laminating plates and bonded under pressure [to form] one unit.

The lenticulation may be embossed during this laminating process by incorporating a negative of the lenticulation into the corresponding laminating plate. A thermostable embossing matrix which is inserted between the transparent cover layer and the laminating plate may be used just as easily.

By all means it also is possible to laminate the cards according to the generally usual process and subsequently introduce the lenticulation by means of an embossing stamp or an embossing roll.

The lenses (cylindrical or spherical lenses) preferably have a width or diameter of 400 μ, and a total thickness around 350 μ is preferably chosen for the transparent, embossed layer.

Informations are preferably introduced into the card by means of a pulse-mode operated laser, e.g., a ND[5]-YAG-laser, where the laser beam 9 is directed under various angles toward the lenticulation. A first information, e.g., in the form of a logo , an emblem or a photo of the card user, are introduced under a perpendicular angle of incidence (Fig. 2a). The data recording preferably occurs in the dot-scanning procedure. For that, the lenticulation is scanned point for point and the intensity of the laser beam is modulated corresponding to the image information. The image generated through that is thus composed of single dots, so-called pixels.

The beam is effectively refocussed when passing through the cylindrical lenses. The writing is thus limited to narrow partial regions 11 in the form of strips lying underneath the center of the single lenses. The information is then present in the form of striation images, where the striations are formed by a sequence of pixels separated from each other. The change in the card material generated by the laser irradiation in terms of shape and location may purposefully be influenced by the suitable choice of the construction of the card, the materials in the layers, their thickness, the structure of the lenticulation and the lens parameters. In the examples of embodiment shown in Fig. 2 a-c, the parameters mentioned above were chosen - also for simplification of the representation - so that the change in the material is restricted to the surface region of the card layer. However, in many cases, such a strict delimitation is not achievable. But rather an optically recognizable material modification will result over a larger depth region, where also bordering layers, e.g., the cover layer, may be locally modified, presumably based on the increased energy density in the refocussed region of the laser beam. However, this is no disadvantage, but rather an advantage, because through that manipulations in which the layers are separated and subsequently reassembled - as mentioned at the outset - do not lead to the desired objective. After introducing this first information, the card is tilted to one side by a certain angle, for example, 27°, or the angle of irradiation is changed correspondingly by placing prisms in the beam, and a second information, which, e.g., sets the period of validity, is introduced in the same way in the form of a striation

[5]Should be Nd.

image 10b. Following, the card is tilted to the other side, preferably deviating by the same angle from the normal to the card, and a third information (striation image 10c, Fig. 2c) is introduced. This information may contain, e.g., card specific data like the account number.

When subsequently viewing the tilt-image, only the information represented by the striation image 10a is visible at a perpendicular viewing angle, while when viewed from the side or after tilting the data carrier the second or third information formed by the striation images 10b or 10c are visible. If the card is tilted even further, then this information disappears again, and after a further rotation of the card into the same direction the bordering striation image belonging to the neighboring cylindrical lenses will appear in the field of view. With that, a new change in information takes place. If after viewing, e.g., the second information the card is tilted further in the same direction, then after a certain angle of rotation the third information appears since this striation images now comes into the "viewing field".

Through the inclination of the card the images would normally fall out of the available depth of field of the laser during recording. However, the cylindrical lenses refocus so that a focusing in the card occurs in any case dependent on the writing angle, although at different depths. This, however, remains unnoticeable to the viewer, so that no differences in the sharpness are recognizable in the entire area of these logos. The relatively large stripe width with which the laser writes to the material also leads to the fact that it turns out not to be a disadvantage that the laser beam is not incident atabsolutely the same angle in each region of the image when [the beam] is moved by the rotation of the deflecting mirror across the lenticulation. Thus, each lens is hit at a slightly different angle than the previous lens.

Even though the single informations are present in a mixed arrangement, at the corresponding viewing angles they are again separately visible. Fig. 3 shows a three-dimensional representation of the partial images visible from different angles. The informations may be completely independent from each other, corresponding to the above mentioned example, or may also be in a certain relation to each other. Thus, e.g., a single motif may be represented in a slightly varied form each for each of the different recording angles (e.g., various views). It is further possible to introduce markings such that for a tilting motion of the card an impression of a moving image is created.

For that, a marking is introduced, e.g., at one end of the lenticulation, starting at a recording angle of approx. 30° from the card normal. While scanning the lenticulation in a transverse direction by means of the laser beam, the recording angle is changed

continuously in one direction or in set steps. Thus, the location of the marking in the data receiving layer shifts relative to the location of the center of the cylindrical lenses, such that when viewing the card - under slight tilting - the impression is created that the marking moves from one end of the lenticulation to the other end.

The introduction according to the invention of partial informations that are visible under various angles may also be used to generate images that give the viewer the impression of a three-dimensional representation. For that, images, e.g., of two views of one motif shot with the geometry of the eye under consideration, are recorded through the lenticulation at the corresponding angles, such that when viewing the image one partial image appears in the viewing angle of the left eye, while the other one in the viewing angle of the right eye. For the viewer, the partial images are put together into one image with a three-dimensional effect.

The recording of the laser data may occur in different ways.

The card core layer 6 equipped with the printed security image and, as the case may be, with further data may, e.g., directly serve as the data carrying layer, as shown in Fig. 2, where the printed security image, from card to card preferably designed aperiodically, may also extend into the region of the lenticulation. There - through the lenticulation - this printed security image is only incompletely visible and with a distorted shape, but under all viewing angles.

In the border regions the lenticulation may also be designed such that the relief structure has a nearly flowing transition into the smooth region of the card surface. Through that, a removal of the tilt-image and its transfer to a forged card is made even more difficult. Also by means of the laser, patterns, e.g., guilloches, may be introduced into the border region of the lenticulation and the surrounding, unprinted region of the card, through which the tilt-image created according to the invention may further be fused with the card.

Preferably, the core layer is a colored plastic layer or a paper layer which discolors under the influence of the laser light, e.g., is blackened.

In a further possible embodiment, an additional data receiving layer that absorbs the laser light well is introduced between the core layer and the transparent cover layer into which the lenticulation is embossed.

For this [embodiment], the core layer is, e.g., coated in the region of the lenticulation with suitable materials, such as metals, color coatings, etc. Materials suitable for a laser recording are known, e.g., from US-PS 4 032 691. Further suitable materials with an aluminum basis are named, e.g., in DE-OS 33 11 882. Under the appropriate control of

the laser intensity, these layers also allow the representation of the motif in different colors.

Fig. 4 shows a particularly advantageous embodiment. There, an additional, transparent plastic layer 16, which has a relatively high absorbing capacity for the laser used, is introduced between the foil with the lenticulation 7 and the core layer 6. Such plastic layers are known from DE-PS 31 51 407 and DEOS 34 25 263. They contain additives, e.g., in the form of colorants, that are used in amounts that practically do not affect the visual transparency, but [which] act as absorption centers for the laser beam and cause a blackening in the plastic layer.

The thickness of this layer and the thickness of the cover layer transparent to the laser are adjusted to each other such that the focusing plane of the lenses falls into the transparent region of the foil.

The foil preferably corresponds to the outer dimensions of the card and is integrated over the entire surface into the composite card. Due to its transparency properties, the data and informations on the layers underneath are further visible. The foil preferably consists of PVC, since it can easily be fused to the neighboring layers by using heat and pressure. The foil may also be a partial layer of the cover foil which, for example, may be conceived as a compound foil consisting of an outer layer not sensitive to laser recording, and an inner layer sensitive toward laser recording. Mechanically stabilized by the other foil, the latter may then be made particularly thin.

If using a laser-writable, transparent plastic foil as the "data receiving layer", when writing to the plastic foil, the pixels 17, i.e., the blackened regions, form differently within the volume of the foil depending on the depth location of the layer within the composite card.

Fig. 4b shows a summarizing representation of the blackenings to be expected for a set lens diameter of 400 μ and a refractive index of 1.5 within a sensitive foil as a function of their intercalation in the various depth regions. For an intercalation near the surface, in this case to a depth of approx. 350 μ, the partial images or the corresponding pixels (33, 34, 35) introduced at three different angles (30, 31, 32) would overlap. But starting from this depth the pixels are separate and the single partial images are separately visible without influencing neighboring pixels (see Fig. 4e - g). In a preferred embodiment, the foil thicknesses of the non-sensitive, embossed foil and of the sensitive foil lying underneath were chosen such that rod-shaped pixels (Fig. 4f) or slightly conical pixels (Fig. 4b) are formed, which were oriented in the direction of the irradiating laser beam. That means that, for lens parameters as shown in Fig. 4b, the laser sensitive foil

with a thickness of, e.g., 100 μ, lies intercalated in the card at a depth between approx. 350 and 600 μ. The partial images that result this way are separated from each other and thus are visually well separated. The small rods are composed of single, microscopically small black regions that form due to the locally limited decomposition of the plastic material. The small rods may also extend into the cover foil, as shown in Fig. 4a and 5. Due to the refocusing, the power density of the laser beam most often is sufficient, especially near the focusing region, to also cause an optical modification in the not sensitive cover foil.

When viewing these images through the cylindrical lenses under the various angles, one always looks down perpendicularly onto the small rods. The small rods themselves are not blackened entirely, but over their length of several 100 μ (depending on the energy of the laser pulse, focus of the lenticulation, sensitivity and thickness of the foil used) they have the necessary optical density that appears as blackening. For this reason, the single images are clearly visible even when the little rods that belong to different partial images touch each other. The intensity of the blackening in these foils may be adjusted in a simple and reproducible way by controlling the intensity of the laser or of the pulse power, such that the representation of half-tone images is also possible.

The small rods that do not belong to the respective partial image are not oriented in the direction of the corresponding viewing angle, so that in any overlap that might occur they are only seen from the side. But when viewed from the side, the optical density is substantially lower and therefore does not have a disturbing effect.

With an increase in intensity of the laser, the small rods broaden. As a consequence of this broadening the information is visible in a larger angular region. Then, by a simple control of the laser intensity one has the ability to introduce informations which are readable only in a small angular zone, but also informations which in the extreme case may be visible from nearly any direction. Thus, e.g., those image parts that are common to all partial images, e.g., a frame, may be introduced from one angle with increased laser intensity, while the various partial informations may be introduced at the corresponding angles with appropriately low laser intensity. With that, based on all partial images the number of laser pulses necessary for the recording decreases, and thus also the time that is necessary to form the tilt-image.

But the image informations may also be introduced directly into the foil equipped with the lenticulation. For that, a foil is chosen which is only weakly sensitive to the laser beam and in which a blackening only occurs when the laser beam is additionally focused, as in this case by the cylindrical lenses. In the focus region the power density is so high

that a decomposition of the plastic material occurs, while outside of the focus the power density is not sufficient for a decomposition of the material.

Lasers with high output power are usually necessary for the blackening of the plastic foil. A suitable laser is, e.g., a Nd-YAG-laser operating in pulse mode with peak pulse intensities between 10^4 and 10^5 watts at a wavelength of 1.064 μ.

The pulse mode suggests recording the image informations in the form of a dot matrix, where each point in the matrix corresponds to a laser impulse. If, as provided by the process according to the invention, informations are introduced by [passing] through the lenticulation, then it usually is to be expected that the scanning with the pulse frequency of the laser over the single lenses must be synchronized, since otherwise irregularities occur in the degree of blackening, depending on whether the laser pulse hits the next lens or not. However, such a synchronizing would be technically very expensive and, as will be shown in the following, may be avoided through the appropriate coordination of the parameters for the diameter of the beam, width of the lenses, speed of scanning and pulse frequency.

For that, the laser beam 9 is dimensioned so that when hitting the lens the diameter is only a fraction of the width of the single lens 15, preferably smaller than 1/3 of the diameter when introducing three tilt-images. Then, the scanning speed and pulse frequency are chosen such that when passing over the lenticulation a plurality, e.g., four laser impulses 18, 19, 20, 21 hit every lens. Therefore, every pixel 17 is created by at least two subsequent laser impulses. If each first laser pulse 18 in this example hits not exactly at the beginning of the lens, its energy is divided between two lenses and the resulting power density is not sufficient for a noticeable blackening, even for the sensitive layer. The second and the following pulses fully hit the lens and cause sufficient blackening for the pixel. In this way moiré fringes that are present in not synchronized recordings are also prevented.

The introduction of the informations by means of a laser beam [passing] through the lenticulation further has the advantage that the demands for the optical quality of the lenticulation is of only subordinate importance. Local defects in the single lenses, which have as consequences, e.g., a deviation of the laser beam different from the neighboring lens and thus a shift of the recorded point, are of no importance since the optical paths during recording and during later viewing are identical. For the same reason it is possible without any problems to vary within the lenticulation the lens shape, arrangement, focus and/or grid period as well as further parameters. Thus, local defects in the lens or intentional local modifications also contribute toward the security against forgery of the

card. If the lenticulation is destroyed by a manipulation and replaced by a new one, then the manipulation is recognizable - even if the forger should succeed in placing a similar lenticulation over the data with an exact fit. A shift of the recorded points caused by a lens defect is then not canceled any more by the replaced lenticulation, and the observed image loses its initial sharpness. When using a transparent plastic layer the small rods are not viewed exactly along their longitudinal axis with the maximum optical density, but at an angle tilted from the longitudinal axis, such that the image has local differences in the degree of blackening.

Compared to a special coating of the core layer, transparent plastic layers as "data receiving layers" have the advantage that the single card layers may be fused equally homogeneously over the entire surface and that the layers may not be separated again. In contrast, a coating in the area of the lenticulation of the core layer usually requires additional measures for obtaining a strong bond between the single layers in this region also.

Besides, an image printed on the card core layer that may be underneath or penetrate the lenticulation, further remains visible. Identification cards are usually provided with a background pattern, where the location of the motif changes aperiodically from card to card. Now, if the background pattern extends into the region of the lenticulation, this measure already prevents the successful transfer of a punched out tilt-image to another card, since the exact fitting of background patterns of different cards is present only in the rarest of cases.

A schematic representation is shown in Fig. 6 of a device for the mechanical checking of the disclosed tilt-image which contains three partial images that are visible in the direction normal to the card and at angular distances of approx. plus 27° and minus 27° from the normal to the card.

The checking device has three light detectors 21, 22, 23 that are composed of several single photodiodes and which form a light sensitive receiving surface. The detectors are pointed at different angles (0°, +27°, -27°) toward the tilt-image 13 present in the card 1. By means of a suitable arrangement of photo stops or additional optical elements (not shown in the Figure) one can make sure that the detectors receive only the light from a small angular region and [that] the viewing field of the detectors is limited to the tilt-image 13 present in the examining device. Further provided in the device are light sources 29 which illuminate the tilt-image. The signals obtained from the single photodiodes of each detector arrangement are added electronically. Since the information from the image is different in the various directions, one thus obtains three different

measured values A (detector 21), B (detector 22) and C (detector 23). These measured values are normalized in a data processing arrangement, e.g., the ratios A/(A + B + C), B/(A + B + C) and C/(A + B + C) are determined, so that a signal is obtained independent of the total brightness. The measured values obtained this way are then compared to values present in memory. Since the tilt-image has card-specific informations in at least one partial image, the values measured will always be different from image to image and from card to card. Now, if the control values are stored directly on the card, e.g., on the magnetic strip or in another coded form of a known kind that is mechanically readable (OCR-code, bar code), one obtains an additional tying of these values to the card. Moreover, the checking of the card may occur by direct comparison of the measured values with the values stored to the card, through which one may save additional central storages etc.

If only the partial images with standard informations are used when examining the tilt-image, then comparative values may also be stored permanently in the examining device.

Instead of an integral measurement, the tilt-image may also be scanned line by line from the various angles and compared to the corresponding values. If the informations, e.g., the account number, are inserted in a mechanically readable code form (e.g., in OCR code), then the characters may also be read directly and those checked.

Fig. 7 shows a further embodiment of the invention. There, the disclosed tilt-images 24, 25 are combined with tilt-images applied by a printing technology 26, 27 or with a 3D-image consisting of two images. The images 26, 27 are included such that they are visible when viewing the card nearly perpendicularly, e.g., from plus 8° and minus 8°. If the card is tilted further into the one or the other direction, the laser tilt-images 24, 25 are recognizable. From a technical viewpoint, a variation of these images 26, 27 from card to card is disadvantageous. It thus makes sense to represent with these informations that are the same for all cards, e.g., logos, the year, etc. The card-specific data are introduced by the laser technology mentioned at the outset. If this is done in a color contrasting way, e.g., in black, the transition from the images 26, 27 to the images 24, 25 is particularly well recognizable.

The manufacture of the card shown in Fig. 7 can be similar to the cards mentioned in the beginning. The embossing with the lenticulation also occurs with laminating plates during the laminating process. The images 26, 27 are applied, e.g., together with the general printed image (background image, guilloches, etc.). When bringing the laminating plates together with the ticking (core layer 6), one only has to pay attention

that the register marks on the printing sheet overlay exactly with the register marks of the laminating plates. If this is the case, the parallel lenses of the lenticulation are automatically parallel to the lines of the printed images 26, 27. After punching out the cards, the register marks are not available any longer, so that no aid is given to the forger, and that the problems mentioned at the outset do exist without change if occasion should arise for manipulation.

But the printed image may also be printed prior to the manufacture of the card to the surface of the cover foil that later will lie on the inside, and the lenticulation may be embossed in exact register with the printed image, or it also may be proceeded in the reversed way (embossing - printing).

The card represented in Fig. 7 has the further advantage that different technologies (laser technology and printing technology) are unified in a visually checkable card feature, which further increase on one hand the multiplicity for variation and on the other the protection against forgery.

Though, with this embodiment one has to take into consideration that the printed image only "tilts" when it is arranged in the focal plane of the lenses of the lenticulation or at least in its close by. Thus, the thickness of the cover foil and the location of the printed image are to be chosen in accordance to the focal length of the lenses. Furthermore one must pay attention that a blackening caused by the laser beam that continues in the cover foil does not overshadow the printing technologically generated printed image. Such problems may also be avoided by using relatively insensitive materials for the cover foil, low laser intensities, as the case may be, in combination with a coating of the card core with laser sensitive material.

However, if one uses a card structure as shown in Fig. 4, in which the laser recording is done within the volume of a transparent plastic layer, the introduction of an additional tilt-image created by printing technological means may be possible by introducing the printed image between the transparent foils. To avoid laminating technological problems caused by heat, or further problems that could occur when introducing the lenticulation in register to the printed image, the cover foil may also be prefabricated with the lenticulation, the printed image printed on its opposite side in register with the lenticulation, and the foil bonded to the other layers of the card in a cold laminating process while using suitable, well adhering adhesives, but which do not influence the lasering.

But a high security against forgery is obtained only through the use of a laser for the recording of a tilt-image, in particular in combination with the recording within the

volume of transparent card layers, because only then a possibility is offered to couple a simple manufacture simultaneously with a high security against forgery and adulteration. The following aspects are particularly valuable for the security against forgery as well as the production engineering:

-The introduction of card-specific data easily realized with the control of the laser, which makes the transfer of a tilt-image from an authentic to a false card senseless.

-The simultaneous introduction of the data into several regions of the layers and namely process technologically in register, so that manipulations in which card layers are separated to gain access to the data are immediately recognized.

-The introduction of the information underneath the lenticulation without any problems of register, where this may be done in already finished cards.

-The irreversible change in the card material caused by the laser, through which a later change, i.e., adulteration of the data is not further possible.

-The application free of problems of showy and unusual lenticulations, e.g., a combination of cylindrical and spherical lenses. For example, the border region of the tilt-image may be designed spherical lenses to be decorative and showy. Through that, the forger which wants to create a forgery of the imprint is forced to make a special embossing raster for each type of card; he cannot refer to the known postcard with lenticulation-tilt-images. Already the effort [necessary] for the reproduction of the unusual and showy lenticulation is thus an effective threshold against imitation.

-The use of lenticulations with lenses of different focal lengths, through which unsurpassable problems result during the generation of reproductions by means of printing technological and photographical means. The tilt-effect is namely present in these reproductions only if the recordings of the partial images come to lie in the focal plane of the lenses. Therefore, the forger is forced to perform the recording of the partial images in a 3-dimensional form. Since the tilt-image created by means of laser, but preferably recorded in the form of small rod-shaped volume elements, this difficulty during the recording through the lenticulation with different focal lengths does not exist for it [the tilt-image]. Besides, due to the rod geometry also the regions underneath the spherical lenses only tilt perpendicular to the direction of recording.

-The ability to achieve for a suitable choice of the recording geometry and arrangement or shape of the lenticulation, a tilt-effect, i.e., a change in information when tilting the card which is not only visible for a rotation of the card around a single preset axis of rotation, but also for rotations of the card around other axes of rotation. A lenticulation is, e.g., shown in Fig. 8 in which the cylindrical lenses are at an angle of 45° to the longitudinal axis of the card. The partial images (10a,b,c) are introduced through line-by-line scanning of the lenticulation 8 of the card, where the scanning occurs along an edge of the card. The various partial images are introduced as described above at various recording angles. But in the arrangement shown here the laser beam during recording does not scan over the cylindrical lenses perpendicular to their longitudinal axis, but at an angle of 45°. Then the partial images introduced this way are visible in an alternating when turning the card around its longitudinal and lateral axis (a,b) as well as an axis running collinear to the diagonal of the card and axis running perpendicular to the longitudinal axis of the lenses.

Such an effect is achieved as soon as the laser beam is guided across the lenticulation at an angle not perpendicular to the longitudinal axis of the cylindrical lenses, but at an angle between 10° and 80°, where, like in the example shown in Fig. 8, the partial images 10 a-e viewable at various angles are visible particularly clearly separated from each other at an angle of 45°. Since it is not necessary to orient the lenses exactly at 45° from the scanning direction, curved, arc-shaped or similarly shaped cylindrical lenses or other lens shapes may be used to achieve the same effect. Furthermore it is possible to orient lenses in different parts of the lenticulation differently, e.g., in the form of a herringbone pattern.

All these points contribute by themselves or in combination to provide data carriers, e.g., identification cards, in a simple way with an authenticity feature that is easy to be checked, difficult to nearly impossible to be imitated and reproduced by copying or photo-technologies. But it proves to be particularly advantageous that the means for attaining the object of the invention point to a simple way to tie close together standard informations (logo, insignia, etc.) with card individual informations (photo, account number, etc.). In the same way further data, e.g., validity period or certain information characterizing the series of cards, may also be included.

Claims

1. Data carrier in which informations are introduced into a region of the inner volume by means of a laser beam, [informations] that are visible in the form of modifications of the optical properties based on an irreversible change in the material caused by the laser beam, **characterized** in that the data carrier comprises at least one transparent plastic layer (7) which at least in one partial region is provided with a surface relief in the form of a lenticulation (5), that at least a part of the informations introduced by laser beam are introduced [passing] through the lenticulation, that the changes of the optical properties is restricted to regions (pixels) whose radial dimension is smaller than the diameter of a single lens, so that based on the optical effect of the lens these [pixel]s are visible in only limited angular regions, and that informations that belong together, extending over the area of the lenticulation, which were recorded using a laser beam at a narrowly delimited angular region may subsequently be read and/or evaluated by a measuring technique at the same narrowly delimited angular region.

2. Data carrier according to claim 1, **characterized** in that a plurality of informations (10a, 10b, 10c) readable from different angles are recorded underneath the lenticulation.

3. Data carrier according to claim 1, **characterized** in that the lenticulation comprises cylindrical lenses.

4. Data carrier according to claim 1, **characterized** in that the lenticulation comprises spherical lenses.

5. Data carrier according to claim 1, **characterized** in that the lenticulation comprises a mixture of cylindrical and spherical lenses.

6. Data carrier according to claim 2 and 3, **characterized** in that the data (10a, 10b, 10c) recorded underneath the lenticulation are present in the form of a mixed image which consists of pixels in such a way that line-like pixel series that are parallel to the longitudinal axis of the axis belong to one partial image, and neighboring pixels perpendicular to the longitudinal axis of the lenses belong to another partial image.

7. Data carrier according to claim 2, **characterized** in that the informations (10a, 10b, 10c) are standard informations such as logo, validity mark, etc., as well as card-specific data such as account number, card number, etc.

8. Data carrier according to claim 1, **characterized** in that by means of appropriately wide pixels that are visible from a larger angular region information details are introduced such that these are readable from different directions.

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9. Data carrier according to claim 1, **characterized** in that a laser-writable, transparent foil (12) is provided the foil (7) carrying the surface relief (15) and a core layer (6).

10. Data carrier according to claim 9, **characterized** in that the foils (7,12) are built as compound foils.

11. Data carrier according to claim 9, **characterized** in that the laser-writable foil(12) is mixed with colorants that are evenly distributed within the foil.

12. Data carrier according to claim 9 or 10, **characterized** in that the optical change in the volume regions of the transparent foils are present in the form of small rod-shaped pixel oriented in the direction of the beam.

13. Data carrier according to claim 5, **characterized** in that the lenses are arranged in a tactile and visually recognizable pattern.

14. Data carrier according to claim 1, **characterized** in that the lenses of the lenticulation have different focal lengths.

15. Data carrier according to claim 1, **characterized** in that the grid period of the lenticulation is smaller than the diameter of the lenses.

16. Data carrier according to claim 1, **characterized** in that the grid period in different partial areas of the lenticulation is different.

17. Data carrier according to claim 1, **characterized** in that the lenticulation consists at least in part of cylindrical lenses with cylinder axis that are not straight lines.

18. Data carrier according to claim 1, **characterized** in that the vertices relative to the surface of the data carrier of lenses arranged next to each other lie at different heights.

19. Data carrier according to claim 1, **characterized** in that the lenses (15) have a lens diameter between 150 µ and 500 µ.

20. Data carrier according to claim 1, **characterized** in that an embossing of the surface is present in the transitional region between lenticulation and the data carrier surface that is not embossed.

21. Data carrier according to claim 20, **characterized** in that the surface embossing has a continuous transition into the lenticulation.

22. Data carrier according to claim 1, **characterized** in that a pattern recorded by means of a laser, e.g., a guilloche, is provided in the border region of the lenticulation.

23. Data carrier according to claim 1, **characterized** in that further informations introduced by printing technological methods are present in at least a partial region of the surface relief (5).

24. Data carrier according to claim 23, **characterized** in that the information that is applied through a printing technology is an aperiodic background pattern.

25. Data carrier according to claim 24, **characterized** in that the background pattern continues in the regions of the data carrier outside the region of the lenticulation.

26. Data carrier according to claim 23 or 24, **characterized** in that the background pattern is a high quality security technological pattern, preferably a guilloche pattern.

27. Data carrier according to claim 23, **characterized** in that the informations (26,27) applied by printing technologies are applied relative to the location and shape of the lenses of the lenticulation in such a way that these informations are visible in only narrowly delimited regions.

28. Data carrier according to claim 27, **characterized** in that these informations contain two images designed to take into account the geometry of the eyes and to be adjusted to the lenticulation, which when viewed simultaneously give a three-dimensional impression.

29. Process for the introduction of informations by means of a laser beam into a data carrier comprising a carrier layer and a transparent plastic layer, **characterized** in that

-the transparent plastic layer is provided in at least one partial region with a surface relief in the form of a lenticulation

-at least one part of the informations is introduced by laser beam [passing] through the lenticulation at a set angle, where

-the laser beam generates an irreversible, optically recognizable change within the inner volume region of the data carrier, and

-this change is limited to a narrower region relative to the diameter of the lens, so that these informations are readable from only narrowly delimited angular regions which essentially correspond to the angular regions from which the informations were introduced by means of the laser beam.

30. Process according to claim 29, **characterized** in that a lenticulation comprising a plurality of cylindrical and spherical lenses is introduced.

31. Process according to claim 29, **characterized** in that various informations are written with the laser at various writing angles.

32. Process according to claim 31, **characterized** in that the writing angle is changed by rotating the data carrier around the optical axis by the corresponding angle.

Translator: Andrea-Ingrid Schneider, 715-549-5734 (German #1126/1995)

33. Process according to claim 31, **characterized** in that the writing angle is changed by guiding the laser beam through prisms and the arrangement of the prisms determine the writing angle.

34. Process according to claim 30, **characterized** in that the laser beam is lead over the lenticulation at an angle perpendicular to the progression of the cylindrical lenses or at an angle between 10° and 80°, preferably 45°.

35. Process according to claim 31, **characterized** in that a first information is introduced with the laser beam hitting perpendicular to the surface of the data carrier (= 0°), a second one with a laser beam hitting at an angle between plus 10° and plus 35°, and a third one at an angle between minus 10° and minus 35°.

36. Process according to claim 31, **characterized** in that informations are introduced at equal angular increments and that the informations are related in such a way to each other that when tilting the card the informations change quasi-continuously from one to another.

37. Process according to claim 29, **characterized** in that the informations are introduced in the dot-scanning procedure and that the informations are composed of the single elements, so-called pixels.

38. Process according to claim 37, **characterized** in that the scanning speed and the pulse frequency of the laser are adjusted such that a plurality of laser pulses hits every lens per pixel when scanning across the lenticulation.

39. Process according to claim 37 or 38, **characterized** in that the layered build-up and the materials used for that are chosen so that the optical changes are caused in volume areas of the transparent layer areas of the data carriers, where rod-shaped pixels are formed.

40. Process according to claim 39, **characterized** in that the pulse power of the laser beam pen is adjusted so that the rod-shaped pixel overlap only little with their volume.

41. Process according to claim 39, **characterized** in that additional informations are introduced by means of the laser for which the radial diameter of the pixel is enlarged by controlling the laser pulse power to such an extent that the pixel is recognizable from a large angular region, and as the case may be from all directions of observation.

42. Process according to claim 29, **characterized** in that in the region of the surface relief printing technological informations are provided in addition to the informations writable by laser, which are arranged and designed so that when interacting with the lenticulation at least a part of this information is also only visible from certain narrow limited angular regions.

43. Process for the checking of a data carrier according to claim 1, **characterized** in that

-the data carrier is illuminated in the region of the lenticulation from various angular regions.

-the light remitted from data carrier regions in which the lenticulation lies is evaluated by a plurality of detectors which each pick up light from a certain angular region.

-the signals obtained from the signals are fed to data processing equipment, processed there and compared to stored values.

44. Process according to claim 43, **characterized** in that the data carrier is scanned in the region of the lenticulation, line-by-line and at various angles.

45. Process according to claim 43, **characterized** in that

-the light remitted at various angles is detected integrally over the entire region of the lenticulation,

-specific angular integrated measured values are created,

-these measured values are normalized by forming ratios and

-the normalized values are compared to stored values.

46. Device for the performance of the process according to claim 43, **characterized** in that

-the device has a plurality of light sources (29) to illuminate the lenticulation existing on the data carrier to be examined,

-the device has a plurality of lightdetectors (21, 22, 23) oriented at various angles facing toward the data carrier (1) that is to be checked, and

-the light detectors (21, 22, 23) are connected by means of a signal line to data processing equipment, in which the measured values are processed and compared to stored values.

47. Device according to claim 46, **characterized** in that the light detectors (21, 22, 23) comprise a plurality of single photodiodes arranged in one plane or in one line.